Expert Report of Agustín Irizarry-Rivera

PROMESA Title III - No. 17 BK 3283-LTS and

PROMESA Title III - No. 17 BK 4780-LTS

United States District Court for the District of Puerto Rico

Submitted April 28, 2023

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I. Introduction

The following organizations: Comité Diálogo Ambiental, Inc., El Puente de Williamsburg, Inc.- Enlace de Acción Climática, Comité Yabucoeño Pro-Calidad de Vida, Inc., Alianza Comunitaria Ambientalista del Sureste, Inc., Sierra Club Inc. and its Puerto Rico Chapter, Mayagüezanos por la Salud y el Ambiente, Inc., Coalición de Organizaciones Anti Incineración, Inc., and Amigos del Río Guaynabo, Inc., has asked that I review the Plan of Adjustment of the Debt ("PAD") submitted by the Financial Oversight and Management Board (FOMB) for the Puerto Rico Electric Power Authority (PREPA)[1].

I have been asked to assess the effect of the proposed PAD on Puerto Rico's public policy that promotes the rapid adoption of distributed renewable energy, a resilient electricity supply for the people of Puerto Rico, and energy justice.

The proposed PAD contradicts this public policy and would hamper the achievement of Puerto Rico's energy independence, energy affordability and energy resilience goals. In Puerto Rico distributed renewables are growing while utility scale renewables are not. The proposed PAD fails to analyze the publicly available data that shows this and simply ignores this fact.

The fixed component of the proposed "legacy charge" is designed to tax the adoption of residential solar energy and it penalizes net metering adoption of solar photovoltaic rooftop generation.

[1] Modified Disclosure Statement for First Amended Title III Plan of Adjustment of the Puerto Rico Electric Power Authority, dated February 21, 2023.

The proposed PAD is based on flawed assumptions on the current rate of adoption of distributed renewable generation, specifically residential rooftop solar photovoltaic systems including energy storage (batteries), resulting in overestimating future energy sales and rendering the proposed PAD unable to repay the uninsured debt it seeks to pay.

My analysis shows that the current Levelized Cost of Energy (LCOE) of residential rooftop solar photovoltaic systems, including batteries, is already less than the cost of electricity from the electric grid. These distributed energy systems are currently equal to the electric grid in cost and superior in terms of reliability and resiliency. Lack of resiliency and reliability from the electricity supplied by the electric grid further drives the adoption of rooftop solar PV systems and is not included in the LCOE calculation.

In short, the proposed PAD fails to recognize, or willfully ignores, the rapid technological change and current accelerated adoption of distributed renewable energy. The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the adoption of distributed renewables and probably increasing grid defection, or partial grid defection. This will result in reduced energy sales and render the proposed PAD useless since to increase revenues further increases in the legacy charge will be needed creating a vicious cycle.

Finally, and for completeness, I include results from a case study in residential electric resiliency thru rooftop solar photovoltaic generation plus batteries.

My conclusions are:

Conclusion 1 – The proposed PAD fails to analyze, or willfully ignores, current rate of adoption of distributed energy.

Conclusion 2 – Renewable energy adoption policy is harmed by taxing the only renewable energy sector growing for the sake of paying an uninsured debt.

Conclusion 3 – Bondholders are experiencing a technological change they did not foresee. Failure to foresee technological change while investing is not cause to change the bonds guarantee whether the bondholders' claims are secured or not. Nor is it cause to tax the new technology as the proposed PAD does.

Conclusion 4 – Based on Levelized Cost of Energy (LCOE) calculations the proposed "legacy charge" is designed to tax the adoption of residential solar energy and it penalizes net metering adoption of solar photovoltaic rooftop generation.

Conclusion 5 – The LCOE of residential rooftop solar photovoltaic systems, including batteries and using equipment of good warranty and LiFePO4 batteries, already cost less than the cost of electricity from the grid after applying the proposed legacy charge.

Conclusion 6 - Contrary to what is assumed in Exhibit P of the proposed PAD significant grid defection could become a reality in Puerto Rico if the proposed legacy charge is implemented, thus rendering the proposed PAD useless.

Conclusion 7 – Rooftop solar photovoltaic systems with batteries are currently less costly than unreliable electricity from the electric grid. This lack of reliability from the electricity supplied by the electric grid will further drive the adoption of rooftop solar PV systems with storage.

Conclusion 8 - The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the adoption of distributed renewables and probably increasing grid defection, or partial grid defection.

Conclusion 9 - Residents of Puerto Rico require a cost effective and resilient alternative to generate electricity and the proposed PAD is an obstacle to achieve this much needed goal.

A description of my qualifications and compensation is available in Section XIII of this Report.

II. Current rate of adoption of net metering solar rooftop photovoltaic systems and batteries in Puerto Rico vs utility scale projects

The Puerto Rico Energy Bureau (PREB) has a public docket named "Performance of the Puerto Rico Electric Power Authority" (docket number NEPR-MI-2019-0007)[2] where LUMA Energy is required to report a number of metrics. The most recent report, dated

[2] The docket is available at https://energia.pr.gov/numero_orden/nepr-mi-2019-0007/.

April 20, 2023, provides data on the incremental installed distributed generation systems capacity. This refers to the number of clients with solar photovoltaic systems (mostly rooftop systems) and wind turbines that register for net metering. If the client does not register into the net metering program the installation will not appear in this statistic. As of April 2023, only 1 client has a wind turbine system, all other clients use solar photovoltaic generation. Figure 1 shows total number of net metering clients with solar photovoltaic generation (bars) and the total generation capacity of these systems in MW.

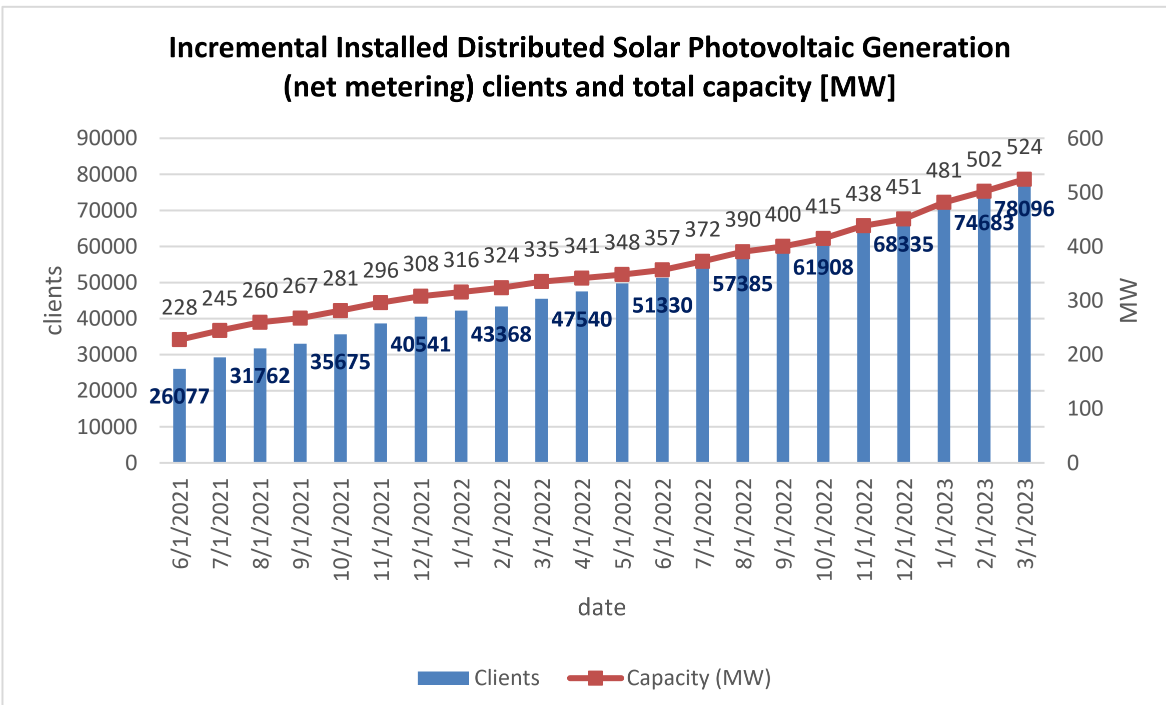

Figure 1. Incremental installed distributed solar photovoltaic generation (registered for net metering) clients and total generation capacity in MW.

Figure 1. shows the increase in solar photovoltaic generation, registered for net metering, since LUMA Energy assumed control of the operation of transmission and distribution. Note that on June 1st 2021, LUMA reported 26,077 registered net metering solar PV systems. As of March 1st, 2023, 21 months later, LUMA is reporting 78,096 registered net

metering clients. In 21 months, the number of net metering clients has tripled. Further notice that **the number of net metering clients is doubling every 15 months**.

The incremental installed capacity shows a similar trend. On June 1st 2021, LUMA reported 228 MW of installed net metering solar PV capacity. As of March 1st, 2023, 21 months later, LUMA is reporting 524 MW of installed net metering solar PV capacity. In 21 months, the installed net metering solar PV capacity more than doubled. It increased by a factor of 2.3. Further notice that **the installed capacity of net metering solar PV systems is doubling every year and a half (doubling every 18 to 19 months)**.

LUMA did not include distributed storage in the April 20, 2023 report to PREB. The most recent energy storage report is dated April 3, 2023 and only includes distributed energy storage data from June 2021 thru December 2022. This is summarized in Figure 2.

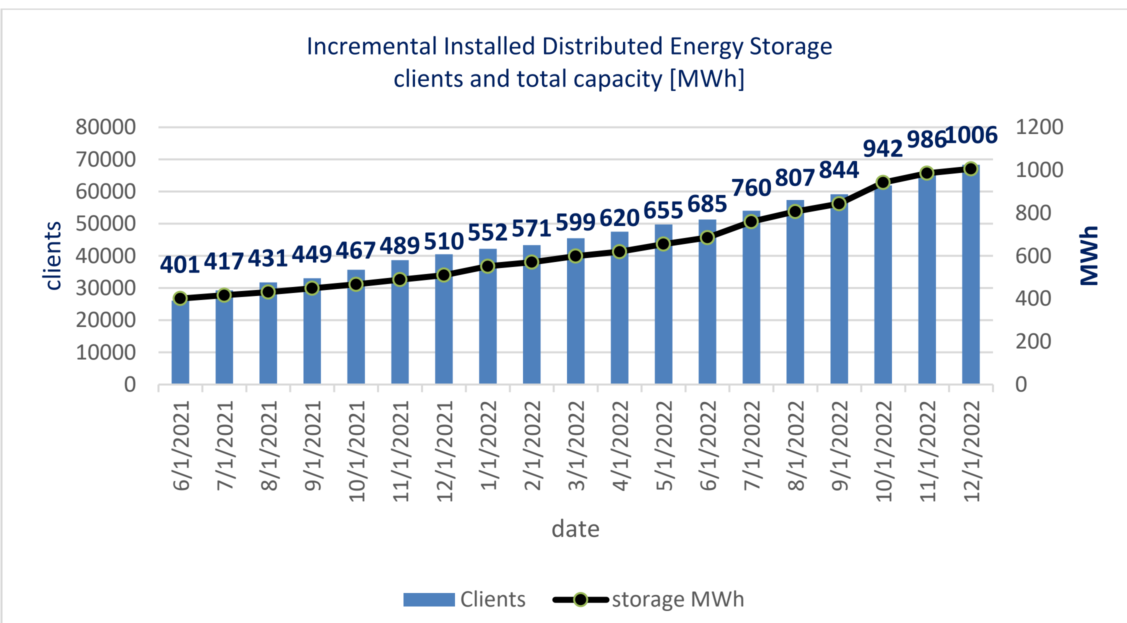

Figure 2. Incremental installed distributed energy storage, in MWh, and corresponding net metering clients from June 2021 thru December 2022 as reported by LUMA to PREB.

On June 1st 2021, LUMA reported 401 MWh of installed distributed electric storage. On December 1st 2022, 18 months later, LUMA reported 1006 MWh of installed distributed electric storage. **From December 1st 2021 to December 1st 2022, one year, the installed distributed electric storage doubled, from 501 MWh to 1006 MWh.**

Thus, the installed generation capacity of net metering solar PV systems is doubling every year and a half (doubling every 18 to 19 months) and the installed distributed electric storage corresponding to these net metering clients is doubling every year.

It is important to note that citizens that install solar PV systems with batteries to serve a portion of their home, disconnecting that portion of the electric load from the grid, do not apply for net metering and therefore are not part of the previous statistics.

On March 30, 2023, the president of the Puerto Rico Energy Bureau, Edison Aviles, declared on a hearing of the Puerto Rico Senate Committee on Strategic Projects and Energy that all tranche 1 utility scale renewable energy projects (18 projects in total) are not under construction as planned due to "differences about the points of interconnection between LUMA and PREPA". Therefore, in Puerto Rico utility scale renewables are not growing while distributed renewables are growing at an accelerated pace.

Puerto Rico Act 17-2019, the Puerto Rico Energy Public Policy Act, indicates on its first paragraph that its purpose is "To create the "Puerto Rico Energy Public Policy Act" for the purposes of establishing the Puerto Rico public policy on energy in order to set the parameters for a resilient, reliable, and robust energy system with just and reasonable rates

for all class of customers; make it feasible for energy system users to produce and participate in energy generation; facilitate the interconnection of distributed generation systems and microgrids, and unbundle and transform the electrical power system into an open system...” Through Law 17-2019 Section 1.6, the Puerto Rico legislature explained that Puerto Rico's energy policy required 40% renewable energy by 2025, 60% by 2040, and 100% by 2050, while keeping electricity prices below 20 cents per kWh. The Legislature also set policy goals of facilitating distributed generation "through any available mechanism", and to encourage use of energy storage. Id.

Is the proposed PAD aligned with Puerto Rico’s renewable energy policy? No. The narrative provided in Exhibit P “Legacy Charge Derivation” shows that the fixed charge of the proposed legacy charge is meant to tax the adoption of distributed renewables, the only renewable sector growing in Puerto Rico.

Exhibit P explicitly states that the fixed charge component of the legacy charge is a sun tax. Quoting from Exhibit P, page 4, “Fixed charges (as opposed to volumetric charges) are preferable as the primary instrument for raising additional revenues, as they are less impacted by the adoption of solar panels by consumers.” In other words – customers can install rooftop solar to lower their energy burden from a volumetric charge – but not a fixed charge. The PAD uses a fixed charge to impose an energy burden on Puerto Ricans that they can only escape by leaving the archipelago or defecting from the grid.

Is the reality of growing distributed solar generation and distributed storage properly captured by the proposed PAD? No. The narrative provided in Exhibit P “Legacy Charge

Derivation" shows that the proposed PAD is completely disconnected from the technological reality of growing distributed solar photovoltaic plus batteries in Puerto Rico.

Conclusion 1 – The proposed PAD fails to analyze, or willfully ignores, current rate of adoption of distributed energy.

Conclusion 2 – Renewable energy adoption policy is harmed by taxing the only renewable energy sector growing for the sake of paying an uninsured debt.

III. Why the fast adoption? Current cost of solar PV and batteries in Puerto Rico and expected decline in cost

The narrative provided in Exhibit P "Legacy Charge Derivation" shows that the proposed PAD is disconnected from the technological reality, specifically cost, of solar photovoltaic plus batteries in Puerto Rico.

The narrative explicitly accepts that the adoption of solar rooftop generation is, from page 4, "relatively attractive for a variety of reasons, including the large number of sunny days per year, the prevalence of buildings with flat roofs, and the generous incentives offered to adopters of solar technology under Puerto Rico law. Consumers purchasing solar panels would see an immediate reduction in their bill from all volumetric charges."

Further quoting Exhibit P, page 4, "To avoid paying such fixed monthly charges, a customer would need to remove themselves from the grid entirely. This in turn would require that a customer install sufficient additional equipment, such as batteries, to ensure

access to reliable electricity at all times (and be willing to take the risk in the event their own generation and storage capabilities did not suffice). While the cost of the required additional equipment is also decreasing and many solar rooftop installations on Puerto Rico already involve some battery capacity, **the cost of installing enough backup capacity to disconnect from the electric grid entirely (and thereby avoid both fixed connection and volumetric charges) <u>will likely remain prohibitive for the vast majority of customers for many years to come (if ever)</u>**." (**<u>Emphasis</u>** provided by the author of this report).

The proposed PAD makes no attempt to justify its assumption that installation cost of energy storage is "prohibitive" and will remain so "for many years to come". In this section we challenge this assumption using representative cost of these systems in Puerto Rico and estimates of declining cost for this technology provided by the US Department of Energy.

Table 1 shows representative real costs of ten (10) rooftop solar photovoltaic residential systems, with LiFePO4 batteries and without batteries, installed in Puerto Rico (2021 cost).

Table 1. Representative real costs of rooftop solar photovoltaic residential systems, with LiFePO4 batteries, in Puerto Rico (2021)

	Total Cost	PV capacity kW	LiFePO4 storage kWh	$/W with storage	Total cost no storage	$/W no storage	LiFePO4 storage kW	Total cost LiFePO4 storage no PV
1	$40,529	5.60	28.8	$7.24	$26,337	$4.70	7.20	$35,319
2	$31,816	6.75	19.2	$4.71	$22,021	$3.26	4.80	$25,844
3	$28,000	6.08	15.0	$4.61	$20,129	$3.31	3.75	$22,472
4	$28,950	5.60	14.4	$5.17	$21,354	$3.81	3.60	$23,740
5	$24,900	3.96	19.2	$6.29	$15,105	$3.81	4.80	$20,777
6	$26,950	3.80	28.8	$7.09	$12,758	$3.36	7.20	$22,933
7	$27,328	6.40	19.2	$4.27	$17,533	$2.74	4.80	$21,588
8	$33,700	7.20	28.8	$4.68	$19,508	$2.71	7.20	$27,430
9	$31,076	7.20	15.0	$4.32	$23,205	$3.22	3.75	$24,806
10	$33,700	7.20	14.4	$4.68	$26,104	$3.63	3.60	$27,430
average	**$29,602**	**6.02**	**19.3**	**$4.92**	**$19,746**	**$3.28**	**4.83**	**$24,113**
minimum	$24,900	3.80	14.4	$4.27	$12,758	$2.71	3.60	$20,883
maximum	$40,529	7.20	28.8	$7.24	$26,337	$4.70	7.20	$34,259

These costs are real cost of installed systems in Puerto Rico as reported by University of Puerto Rico investigators[3] and currently being used in "The Puerto Rico 100 Study"[4].

Total cost includes: equipment (solar panels, inverter, charge controllers (if not included within the inverter), batteries), "balance of system" items (mounting racks, nuts and bolts, electrical tubing, wires, electric protection, electrical boxes) design, installation, retrofit (if needed) and profit.

PV capacity refers to the total installed generating capacity of the solar photovoltaic array, in thousands of Watts (kW).

Lithium ion batteries (specifically LiFePO4) are used in every installation. The storage capacity is shown in Table 1 in kWh.

Total system cost for a system with no batteries, but ready to add batteries, is estimated by subtracting the actual cost of LiFePO4 batteries in Puerto Rico (2021, $458.06 per kWh) and installation cost for the batteries ($1,000).

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[3] The data in the Total Cost and Total Cost - No Storage columns was obtained from reports submitted to the Puerto Rico Grid Resilience and Transitions to 100% Renewable Energy Study (PR100) by Members of the Puerto Rico Energy Recovery and Resilience Advisory Group. The figures in the rest of the columns were derived from that Total Cost data. The data submitted to the PR100 Study is attached as **Exhibit 1**

[4] Puerto Rico Grid Resilience and Transitions to 100% Renewable Energy Study (PR100), - https://www.energy.gov/gdo/puerto-rico-grid-resilience-and-transitions-100-renewable-energy-study-pr100.

The storage package capacity, in kW, is calculated from the energy capacity, in kWh, dividing by 4 hours.[5]

Total storage package, including inverter cost, is estimated by subtracting: the actual cost of solar panels in Puerto Rico (2021, $0.55/W), panels rack cost ($180 per 4 panels, 400 W panels) and installation cost for the rooftop solar panels ($1,500).

For the ten rooftop solar systems described in Table 1 above, I calculated a "dollar per installed W" ($/W) index for both the system with batteries and the system without batteries for comparison. The average installed cost of a system without batteries is $3.28/W. The average installed cost of a system with LiFePO4 batteries is $4.92/W. Figure 3 summarizes this comparison graphically.

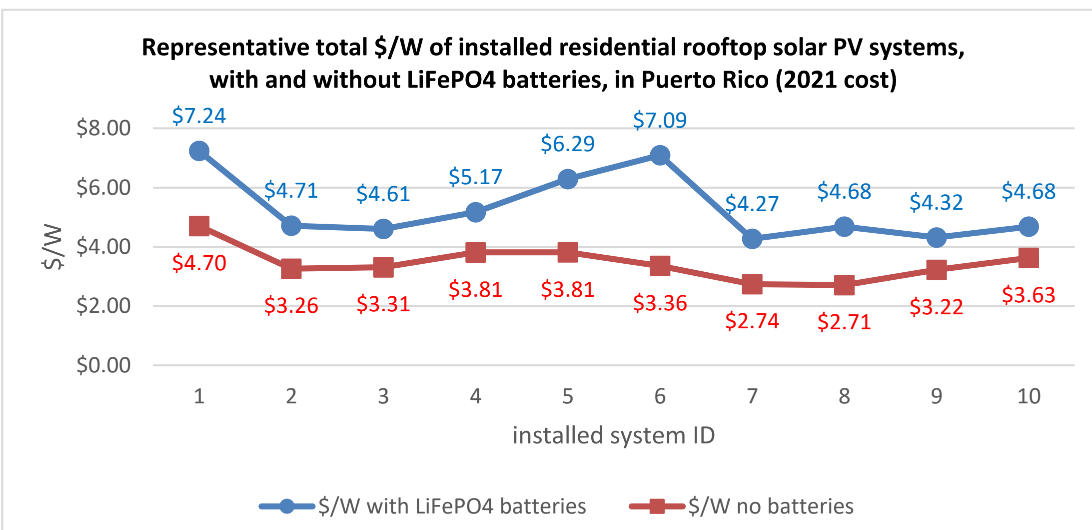

Figure 3. Representative total $/W of installed residential rooftop solar photovoltaic systems, with and without LiFePO4 batteries, in Puerto Rico (2021 data).

[5] For the "average" system in Table 1 divide 19.3 kWh/4 h = 4.83 kW. This capacity is of the total storage package only and not to be confused with the 6 kW of installed solar panels in the same "average" system.

Contrary to the assumptions in Exhibit P "Legacy Charge Derivation" of the proposed PAD the cost of residential solar photovoltaic systems with batteries continues to decrease. How fast is the cost declining? How to estimate the expected reduced cost of these systems in the future?

The National Renewable Energy Laboratory (NREL) specializes in the research and development of renewable energy, energy efficiency, energy systems integration, and sustainable transportation. NREL is a federally funded research and development center sponsored by the Department of Energy.

NREL produces the Annual Technology Baseline (ATB) as "a consistent set of technology cost and performance data for energy analysis"[6]. NREL's ATB predicts the declining cost of this, and other, technologies. Three scenarios are normally calculated: conservative, moderate and advanced.

In the conservative scenario it is assumed that historical investments come to market with continued industrial learning. Technology looks similar to today, with few changes from technology innovation. Public and private research and development (R&D) investment decreases.

In the moderate scenario it is assumed that innovations observed in today's marketplace become more widespread, and innovations that are nearly market-ready today come into the

[6] NREL (National Renewable Energy Laboratory). 2022. "2022 Annual Technology Baseline." Golden, CO. https://atb.nrel.gov/.

marketplace. Current levels of public and private R&D investment continue. This scenario may be considered the expected level of technology innovation.

In the advanced scenario it is assumed that innovations that are far from market-ready today are successful and become widespread in the marketplace. New technology architectures could look different from those observed today. Public and private R&D investment increases.

In our analysis we only consider the conservative and moderate scenarios. The expected declining capital cost of residential solar photovoltaic systems, according to NREL ATB 2022 model in $/W, is shown in Figure 4.

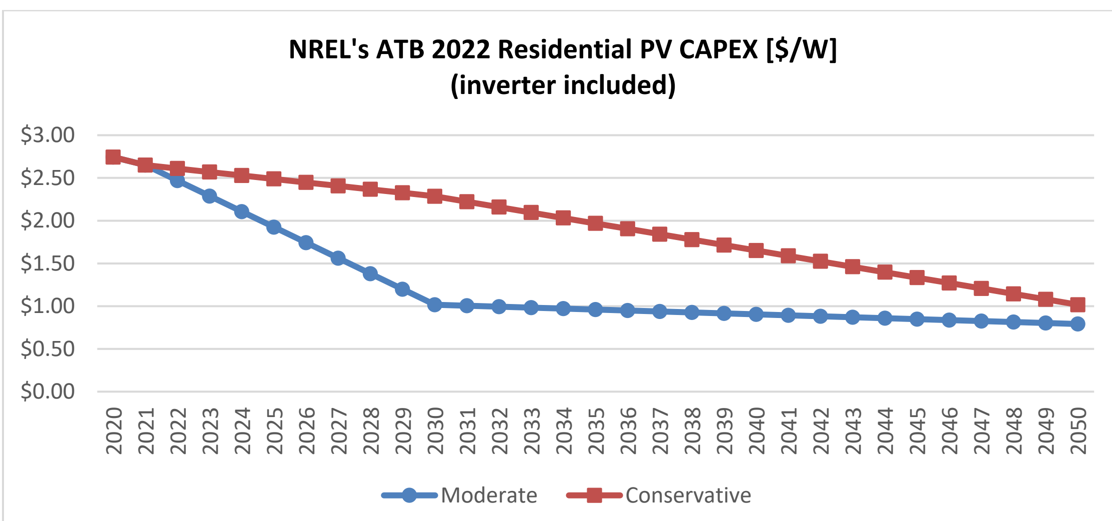

Figure 4. Declining capital cost of residential solar photovoltaic systems based on NREL ATB 2022.

We calculate the declining cost of rooftop solar based on the trajectories established by NREL ATB and the 2021 Puerto Rico's average cost of solar rooftop photovoltaic systems with no batteries, as shown in Figure 5.

Note that the cost in Puerto Rico, in 2021, is \$3.28/W while NREL's cost in the same year is \$2.65/W. The difference in cost is due to the type of inverter used in the representative Puerto Rico installations, a more expensive hybrid inverter, one that is ready to add batteries.

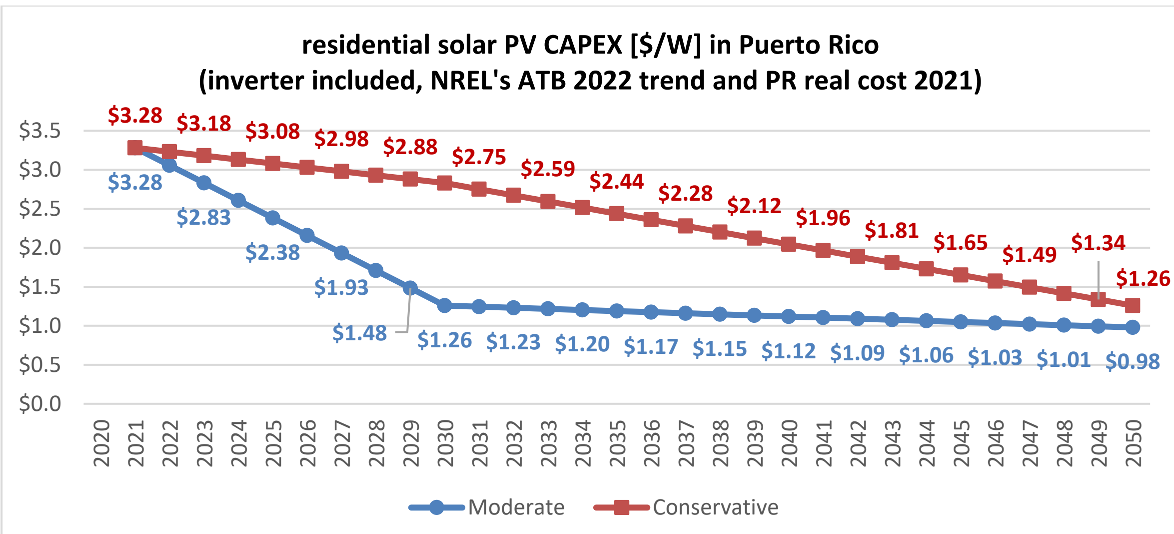

Figure 5. Declining cost of rooftop solar (trend from NREL ATB 2022) and the 2021 Puerto Rico's average cost of solar rooftop photovoltaic systems with no batteries.

The expected declining total cost of residential lithium ion battery systems (5 kW - 20 kWh, i.e. 4 hours of storage), according to NREL ATB 2022 model, is shown in Figure 6.

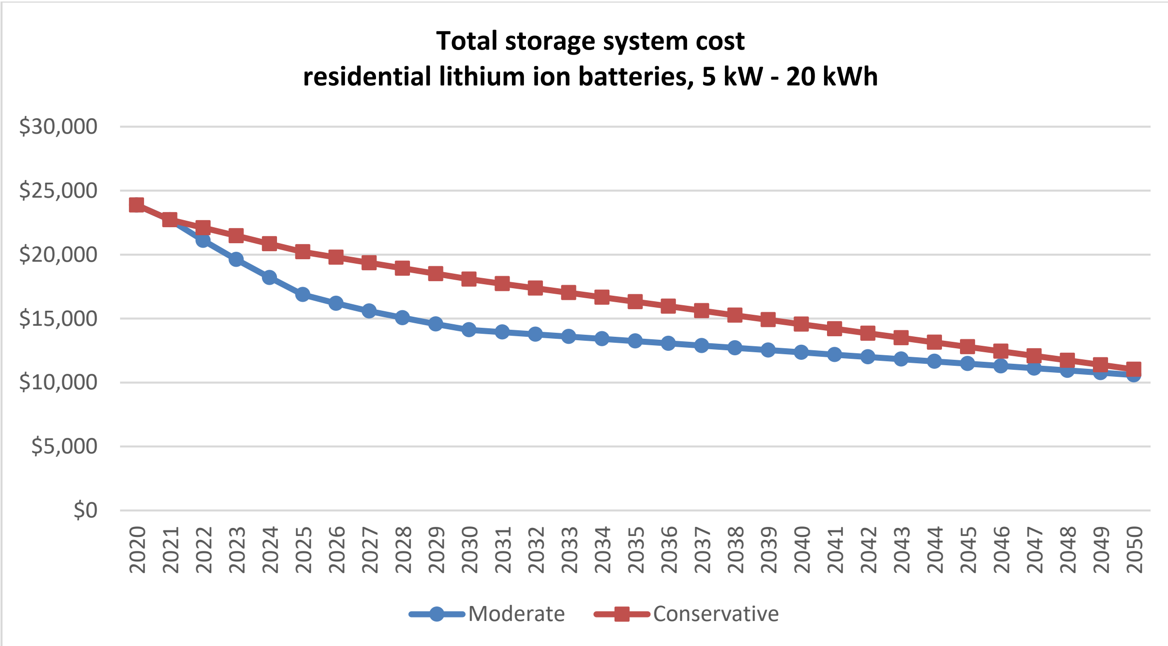

Figure 6. Total storage system cost for residential Li ion batteries in the US, ATB 2022.

From Table 1 the average cost of a storage system package in Puerto Rico, for lithium ion (LiFePO4) batteries was $24,113 in 2021. We calculate the declining total cost of residential lithium ion battery systems based on the trajectories established by NREL ATB and the 2021 Puerto Rico's average cost, as shown in Figure 7.

Note that total storage cost in Puerto Rico, in 2021, is $24,113 while NREL's cost in the same year is $22,725. Further note that the average storage system size is 4.8 kW and 19.3 kWh, very similar to NREL's values of 5 kW 20 kWh.

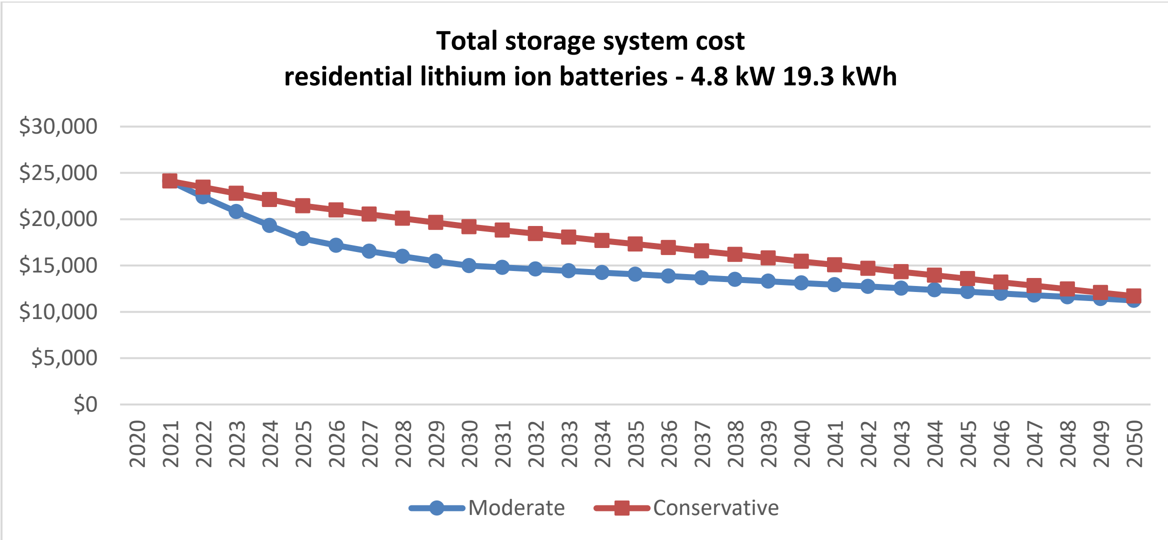

Figure 7. Estimated declining total cost of storage (trend from NREL ATB 2022) and the 2021 Puerto Rico's average cost of storage.

The proposed PAD is disconnected from the technological reality, specifically the cost of solar photovoltaic plus batteries in Puerto Rico. The rapid decline in cost of distributed solar photovoltaic generation plus energy storage is completely overlooked by the proposed PAD.

Conclusion 3 – Bondholders are experiencing a technological change they did not foresee. Failure to foresee technological change while investing is not cause to change the bonds guarantee whether the bondholders' claims are secured or not. Nor is it cause to tax the new technology as the proposed PAD does.

IV. Levelized Cost of Energy (LCOE): definition, uses and limitations

The US Department of Energy (NREL) defines the levelized cost of energy (LCOE) as "LCOE is a summary metric that combines the primary technology cost and performance parameters: capital expenditures, operations expenditures, and capacity factor."[7]

LCOE can be useful to assess the effect of technology advances in future projections because it accounts for primary cost (e.g., up-front capital costs, financing cost) and key performance parameters (e.g., capacity factor) when comparing different technology innovation scenarios.

But LCOE does not capture the full value to the user of reliable electric service, i.e., the electricity worth.

Furthermore, LCOE does not capture the economic value of a particular generation type to the system and therefore may not serve as an appropriate basis for comparisons between technologies. This is so because LCOE ignores attributes that can vary significantly across different technologies (both in terms of capability and cost) such as ramping, startup, and shutdown that could be relevant for more detailed evaluations of generator cost and value to the system.

In this report we use LCOE as an indicator, an index that quantifies the relative cost of electricity when comparing rooftop solar photovoltaic systems, with and without batteries and connected and disconnected from the grid, vs the current cost of electricity from the grid or the estimated cost of electricity under the proposed PAD.

[7] *Levelized Cost of Energy,* Nat'l. Renewable Energy Lab, https://atb.nrel.gov/electricity/2021/definitions.

Table 2 summarizes the parameters used in the calculation of LCOE for all cases. The parameters specific to each case are discussed in the corresponding section of this report.

Table 2. Parameters, and values, used in the calculation of the Levelized Cost of Energy

parameter and units	**parameter value**
rooftop solar PV system capacity (solar panels capacity) in kW	5
capacity factor, dimensionless	0.174 (17.4%)
discount rate, dimensionless	0.435 (4.35%)
ideal annual energy yield, kWh	7621.2
annual energy yield reduction, dimensionless	0.005 (5%)
system lifetime, years	25
annual operation and maintenance (O&M) cost PV only, $	16
annual operation and maintenance (O&M) cost PV + storage, $	71

In the following sections we present the LCOE for two different scenarios: (1) rooftop solar PV systems with net metering and no batteries vs. the current electricity cost from the electric grid to residential end users, and (2) rooftop solar PV systems with batteries disconnected from the electric grid (grid defection) vs estimated electricity cost from the electric grid to residential end users under the proposed PAD.

V. Levelized Cost of Energy (LCOE) of rooftop solar PV systems with net metering and no batteries vs. current electricity from the grid cost

We calculate the LCOE of rooftop solar PV systems, 2021 system cost with a net metering contract and no storage, for a 5-kW solar system with capital cost of $3.28/W (average

value from Table 1), fixed operation and maintenance cost of $16/year (a value equal to the average value on the moderate scenario in NREL's ATB 2022) and utility interconnection cost of $4/month, or $48/year the current interconnection cost, to be 16 ¢/kWh (0.16 $/kWh)[8].

The LCOE for the same system, and same 2021 cost, with utility interconnection cost of $17/month, or $204/year the proposed interconnection cost due to the fixed component of the legacy charge, to be 18.1 ¢/kWh (0.181 $/kWh). **The fixed component of the legacy charge becomes an immediate solar tax of 2.1 ¢/kWh.**

Note that we calculate LCOE for a system installed using 2021 costs. Since the actual cost is declining a system installed in the future, say 2025, will result in a 2025 LCOE smaller than the 2021 LCOE. For example, using $2.38/W as the capital cost (from Figure 5, ATB 2022 moderate scenario trend) the resulting LCOE is 14 ¢/kWh (0.14 $/kWh).

Conclusion 4 – Based on Levelized Cost of Energy (LCOE) calculations the proposed "legacy charge" is designed to tax, therefore penalize, the adoption of residential solar energy thru net metering.

[8] For comparison ATB 2022 list the LCOE for a residential solar PV system with no batteries as 8.3 ¢/kWh, about half of our calculated value. Reasons for this discrepancy are: the inverter cost assumed by NREL in the ATB are much lower than the inverter cost in Table 1 (a hybrid inverter capable of adding batteries), and NREL also incorporates in its financial components tax credits available in the continental US and not available in Puerto Rico.

VI. Levelized Cost of Energy (LCOE) of rooftop solar PV systems with batteries, system disconnected from the grid vs. electricity from the grid with proposed PAD cost

We calculate the LCOE of rooftop solar PV systems, 2021 system cost with storage, for a 5-kW, 20 kWh solar system, disconnected from the electric grid. We use total capital cost of $4.92/W (average value from Table 1), fixed operation and maintenance cost of $71/year (a value equal to the average value on the moderate scenario in NREL's ATB 2022) and no utility interconnection cost.

Since the selected lifetime of the project is 25 years, we include the cost of one battery bank replacement in year 12, $7,635. We use the battery cost in year 12 as per the decline established in the moderate scenario of the ATB 2022 for lithium ion batteries. The LCOE is 27.8 ¢/kWh (0.278 $/kWh).

The Puerto Rico Electric Power Authority (PREPA) Executive Director must provide monthly reports to its Governing Board. The February 2023 version of this report[9] indicates that the average cost of residential electricity, fiscal year to date (i.e., July 2022 thru February 2023, 9 months) was 28.41 ¢/kWh.

Thus, the current electricity cost from the electric grid, prior to the proposed PAD, is already more expensive than grid defection cost thru rooftop solar photovoltaic generation with storage.

[9] PREPA, *Monthly Report to the Governing Board* (Feb. 2023), https://aeepr.com/es-pr/investors/FinancialInformation/Monthly%20Reports/2023/February%202023.pdf.

The average annual solar PV electricity generation of the 5 kW/20 kWh system is 7,145 kWh, or 595.4 kWh per month. Under the proposed PAD a residential client buying this amount of electricity from the grid will pay:

$17 + 500*(0.2841 + 0.0075) + 95*(0.2841 + 0.03) = $192.64, which results in 32.37 ¢/kWh for unreliable electric service.

The imposition of the proposed legacy charge with the subsequent electric energy price increase, a price increase associated to unreliable electric power, and the declining prices of rooftop solar photovoltaic systems plus batteries will create an incentive for customers to permanently disconnect from the electric grid. This is called "grid defection".

A 2014 study[10] shows that in places like Hawaii the conditions for grid defection are already present. The 2018 average price of residential electricity in Hawaii varies from 31 ¢/kWh to 37 ¢/kWh. As we have calculated in this report the cost of un-reliable electric energy in Puerto Rico, after the proposed legacy charge will be approximately 32 ¢/kWh.

Contrary to what is assumed in Exhibit P of the proposed PAD significant grid defection could become a reality in Puerto Rico if the proposed legacy charge is implemented.

Further note that we calculate LCOE for a system installed using 2021 costs. Since the actual cost is declining a system installed in the future, say 2025, will result in a 2025 LCOE smaller than the 2021 LCOE. For example, using $3.65/W as the capital cost (using

[10] "The Economics of Grid Defection: When and Where Distributed Solar Generation Plus Storage Competes with Traditional Utility Service", The Rocky Mountain Institute and others, 2014.

the ATB 2022 moderate scenario declining cost trend for batteries, similar to Figure 7) the resulting LCOE is 22 ¢/kWh (0.22 $/kWh).

Conclusion 5 – The LCOE of residential rooftop solar photovoltaic systems, including batteries and using equipment of good warranty and LiFePO4 batteries, already cost less than the cost of electricity from the grid after applying the proposed legacy charge.

Conclusion 6 - Contrary to what is assumed in Exhibit P of the proposed PAD significant grid defection could become a reality in Puerto Rico if the proposed legacy charge is implemented, thus rendering the proposed PAD useless.

VII. The legacy charge will not improve electric grid reliability

The proposed PAD fails to include needed investments in the electric grid to achieve reliable electric service. This failure will only drive further adoption of distributed solar energy and reduce sales.

One metric used to measure the reliability of U.S. electric utilities is the System Average Interruption Duration Index (SAIDI), which measures the total time an average customer experiences a non-momentary power interruption in a one-year period[11]. For utilities that report SAIDI metrics using Institute of Electrical and Electronics Engineers (IEEE) standards, LUMA follows this practice, non-momentary interruptions are those lasting longer

[11] 1366-2012 - IEEE Guide for Electric Power Distribution Reliability Indices.

than five minutes. SAIDI is often paired with the System Average Interruption Frequency Index (SAIFI), an index that measures the frequency of interruptions.

The Energy Information Administration (US Department of Energy) reports, for 2021, an average SAIDI of 121.5 minutes and an average SAIFI of 1.03 interruptions per customer[12]. Using data reported by LUMA to the Puerto Rico Energy Bureau (PREB) in 2022 the annual distribution system SAIDI was 1,022 minutes and the annual distribution system SAIFI was 4.7 interruptions per customer[13].

In January 2023, LUMA reported 2,417.75 minutes of outages, per customer served, for the eighteen months between June 2021 and December 2022. This is a significant drop in performance compared to the expected performance, measured by the baseline set by the Puerto Rico Energy Bureau, of 1,864.15 months for 18 months.[14]

In the summer of 2021, LUMA reported that the average time for restoration of a customer's electric service following an outage had increased significantly 25 out of 26 regions of Puerto Rico.[15] The average system-wide time to restore electric service after an interruption increased from 2 hours and 43 minutes during June, July and August 2020 to 4 hours and 38

[12] *Table 11.1 Reliability Metrics of U.S. Distribution System*, U.S. Energy Infor. Admin. https://www.eia.gov/electricity/annual/html/epa_11_01.html
[13] https://energia.pr.gov/wp-content/uploads/sites/7/2023/03/Resumen-Metricas-Master_Jan2023_Revised-1.xlsx
[14] Submission of Corrected Spreadsheets on Performance Metrics Quarterly Report for October through December 2022, and Corrected Data on Reliability Metrics for July through August 2022, PREB Docket NEPR-MI-2019-0007 (March 3, 2023)
[15] *Id.*

minutes during June, July and August 2021.[16] Puerto Ricans across the archipelago reported lost food and medicine and damaged appliances from frequent outages:

- "Ashlee Vega, who lives in northwestern Puerto Rico, said the power fluctuations this month were so imperceptible that it took her several hours to realize her appliances were not working right. The new refrigerator she had bought in February - to replace an old one that gave out after enduring years of volatile electrical surges - was fried."[17]
- "It has been hard to expand the business as frequent power cuts force him to close the store and also damage the fridges, which are costly to repair."[18]
- "In early August, the Independent Consumer Protection Office said it had received about twice as many monthly complaints under LUMA than it had when PREPA managed the grid; the complaints have been primarily related to service disruptions and equipment damaged by voltage fluctuations."[19]
- "The latest outage unleashed a flood of complaints on social media as anger spread among thousands of people who were forced to throw out food and refrigerated medication including insulin in recent dats. Some also complained about damaged appliances as lights flickered on and off since Thursday's outage that left 900,000 people in the dark.[20]

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[16] *Id*.
[17] Patricia Mazzei, *Why Don't We Have Electricity?: Outages Plague Puerto Rico,* N.Y. TIMES (Oct. 19, 2021), https://www.nytimes.com/2021/10/19/us/puerto-rico-electricity-protest.html.
[18] Nina Lakhani, *We want sun: the battle for the solar power in Puerto Rico*, THE GUARDIAN (Oct. 18, 2021) https://www.theguardian.com/environment/2021/oct/18/puerto-rico-solar-power-climate-resilience.
[19] Cathy Kunkel & Tom Sanzillo, Puerto Rico Grid Privatization Flaws Highlighted in First Two Months of Operation (August 2021) http://ieefa.org/wp-content/uploads/2021/08/Puerto-Rico-Grid-Privatization-Flaws-Highlighted-in-First-Two-Months-of-Operation_August-2021.pdf.
[20] *Massive power outage in Puerto Rico affects hundreds of thousands amid growing outrage*, CBS NEWS (June 16, 2021), https://www.cbsnews.com/news/puerto-rico-power-outage-latest-2021-06-16/.

- "Irizarry worried for his safety ... and the growing list of appliances lost to unexpected voltage changes. .... The unreliable electricity damaged the freezer where he stored pizza ingredients. ...'We are talking about scenarios where voltage changes have been dramatic and they have destroyed medical equipment and burned down houses...'"[21]
- "Residents of the island say the power cuts have damaged appliances and can be life-threatening to those who rely on certain medical machines."[22]
- "The list of recent incidents includes massive power outages and an increase in power surges. These, along with daily complaints of citizens' damaged equipment, are some examples of the company's inability to manage a complex system."[23]

Conclusion 7 – Rooftop solar photovoltaic systems with batteries are currently less costly than unreliable electricity from the electric grid. This lack of reliability from the electricity supplied by the electric grid will further drive the adoption of rooftop solar PV systems with storage.

Conclusion 8 - The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the

[21] María Luisa Paúl, *Two major power outages in a week fuel fear in Puerto Rico – and memories of Hurricane María*, THE WASHINGTON POST (June 18, 2021), https://www.washingtonpost.com/nation/2021/06/18/puerto-rico-power-outages/.
[22] *Puerto Ricans March to Protest Ongoing Power Outages After Privatization of Electric Grid*. DEMOCRACY NOW! (Oct. 18, 2021). https://www.democracynow.org/2021/10/18/headlines/puerto_ricans_march_to_protest_ongoing_power_outages_after_privatization_of_electric_grid.
[23] Johnny Irizarry Rojas, *Four years after María, Puerto Rico's power grid still in shambles | Commentary,* ORLANDO SENTINEL (Sept. 22. 2021), https://www.orlandosentinel.com/opinion/guest-commentary/os-op-puerto-rico-power-grid-in-shambles-20210922-w6cwdrrgwffzrb25ruylhigsmy-story.html.

adoption of distributed renewables and probably increasing grid defection, or partial grid defection.

VIII. Is the public guaranteed continuity of electric service under the proposed PAD?

Is the public guaranteed continuity of electric service under the PAD? No.

The PAD does not mention reliability[24] of electric energy service, nor it explain how the legacy charge will provide for a resilient[25] electric power system for the public[26]. Thus, the PAD completely ignores the primary reason a utility has been granted a monopoly in exchange for cost-based regulated rates, the obligation to serve and provide an essential service.

The legacy charge sole purpose is to collect money to pay old debt. The legacy charge collects no money to invest on the electric grid in order to make it more reliable and

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[24] NERC is the North American Electric Reliability Corporation; the entity certified by the Federal Energy Regulatory Commission (FERC) to establish and enforce reliability standards for the interconnected bulk power system in North America (www.nerc.com). NERC's definition of reliability is the degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability may be measured by the frequency, duration, and magnitude of adverse effects on the electric supply.

[25] From the Presidential Policy Directive (PPD) 21 "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents." https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil.

[26] "Without some numerical basis for assessing resilience, it would be impossible to monitor changes or show that community resilience has improved. At present, no consistent basis for such measurement exists. We recommend therefore that a National Resilience Scorecard be established." - National Research Council. 2012. Disaster Resilience: A National Imperative. Washington, DC: The National Academies Press. https://doi.org/10.17226/13457.

resilient. This leaves PREPA with inadequate funds to even keep the system from deteriorating further, let alone improving. In fact, section VIII. Certain Risk Factors to Be Considered of the proposed PAD (page 356) indicates "*The Certified Fiscal Plan projections account for the implementation of rate adjustments necessary to meet PREPA's operational and capital expenditure needs. For example, during the first 10 years, PREPA will need to provide an additional approximately $500 million (or 5% of the approximately $10 billion paid over 10 years) of cost share to access FEMA funding that was not included in the Certified Fiscal Plan. Moreover, benchmarking PREPA against comparable utilities suggests that it may need to spend an additional $93 million, increasing to $125 million on capital expenditures annually between Fiscal Years 2035 to 2051.*"

Thus, proposed PAD recognizes that the cost of providing reliable electric service from the electric grid will be higher that the estimated electricity cost of 32 ¢/kWh including legacy charge. Is this estimate, approximately $2.5 billion, enough to provide reliable electric service? No. Estimates of required capital investment to increase reliability are much higher as discussed in the following section.

a. Puerto Rico's electric energy delivery infrastructure is weak

Puerto Rico's electric energy delivery infrastructure, the Transmission and Distribution (T&D) network, is weak as shown by its failed performance during a series of events prior

to Hurricanes Irma and María[27], and by its performance after Hurricane María[28] and recently Hurricane Fiona[29]. The fiscal year (2022-23) to date average residential electric energy cost in Puerto Rico is 28.4 ¢/kWh. **Thus, the new rate of electricity, including the legacy charge, will provide unreliable electricity at a cost of approximately 32 ¢/kWh if the current fuel prices remain as they have been in from July 2022 thru February 2023.**

How much money is necessary to invest in the T&D network to obtain a reliable electric energy supply? Different studies provide different estimates of needed investment to achieve a reliable electric system.

The following Table[30], an estimate from 2017, summarizes the estimated rebuild cost needed to "harden and enhance the resiliency of PREPA's system".

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[27] Prior to Hurricane María a fire at the switchyard of Aguirre generation station in September 2016 caused a complete blackout in Puerto Rico that lasted days. https://www.nytimes.com/2016/09/22/us/fire-at-power-plant-leaves-puerto-rico-in-the-dark.html.

[28] I. Umair, "Puerto Rico's blackout, the largest in American history, explained," Vox, 08-May-2018. [Online]. Available: https://www.vox.com/2018/2/8/16986408/puerto-rico-blackout-power-hurricane.

[29] https://www.politico.com/news/2022/09/18/hurricane-fiona-knocks-out-puerto-ricos-power-00057387.

[30] Table adapted from the Executive Summary of "Build Back Better: Reimagining and Strengthening the Power Grid of Puerto Rico", Puerto Rico Energy Resiliency Working Group members and Navigant Consulting, Inc., A Report for Governor Andrew Cuomo, New York, Governor Ricardo Rosselló, Puerto Rico and William Long, Administrator FEMA, December 2017. www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/PRERWG_Report_PR_Grid_Resiliency_Report.pdf.

Table E-1. Rebuild Cost Summary

Item	Rebuild Recommendations	Total (millions, US$)
1	Overhead Distribution (includes 38 kV)	$5,268
2	Underground Distribution	$35
3	Transmission - Overhead	$4,299
4	Transmission - Underground	$601
5	Substations – 38 kV	$856
6	Substations – 115 kV & 230 kV	$812
7	System Operations	$482
8	Distributed Energy Resources	$1,455
9	Generation	$3,115
10	Fuel Infrastructure	$683
	Total Estimated Cost	**$17,606**

Items 1 thru 6, inclusive, account for almost $12 billion needed according to this study, for electric grid "hardening".

A more recent estimate, December 2022, from the Puerto Rico Department of Housing, estimates that Puerto Rico will need a capital investment of about $6.4 billion in the electrical system beyond the federal funds available.[31]

[31] DEP'T OF HOUS. Puerto Rico Disaster Recovery Action Plan for the Use of CDBG-DR Funds for Electrical Power System Improvements at 77 (Dec. 16, 2022).

The Plan of Adjustment is proposing to emit $5.68 billion in new bonds at between 6% and 6.75% interest and accepts that this is not enough. The proposed PAD underestimates the required capital investment to achieve reliable electric service by assuming a mere $2.5 billion are needed. The required investment is much more.

Does this investment guarantee continuity of electric service after a strong Hurricane? No. It is virtually impossible to protect every element of the T&D system from falling trees, flying debris, landslides due to flooding, and the most severe hurricane winds.

Is there an alternative? Yes. Distributed and renewable electric energy generation plus electric storage provides a better investment in Puerto Rico and in places with high electricity costs, severe local reliability challenges or both. As presented in this report by 2025 solar photovoltaic electric energy plus storage will cost around 22 ¢/kWh while the current cost + legacy charge shall produce a cost of about 32 ¢/kWh,

Are rooftop solar photovoltaic systems impervious to hurricanes? No. But our experience during Hurricane María shows that when properly installed even a modest rooftop photovoltaic system can provide resiliency and continuity of electric service post a major hurricane.

IX. Resiliency thru Distributed Renewable Energy

A case study article[32] describes how electric service resiliency is achieved thru the adaptation of a relatively small existing residential photovoltaic system, originally grid-tied under a net metering agreement with the utility, to a stand-alone system with batteries to provide continuity of service after Hurricane María destroyed Puerto Rico's electric transmission and distribution system.

A modest rooftop photovoltaic system with batteries (1 kW in solar panel capacity, 10 kWh of energy storage, total cost of $2,812) provided resiliency and continuity of electric service post hurricane María. The electric service from the grid, at the location under study, stopped 20 September 2017 and was restored 132 days later, on 30 January 2018. It took 31 days of old fashioned "walk around" to obtain the necessary equipment (charge controllers, batteries, off-grid inverter) to adapt the net metering system into a stand-alone system[33]. The rooftop solar photovoltaic system operated uninterrupted for 101 days, until the electric service from the grid was restored. The system was later re-connected to serve as a net metering system and backup in the event of grid service failure.

In the article the authors also contrast the cost of buying and operating the photovoltaic system to the cost of buying and operating a gasoline emergency generator to supply the

[32] A. Irizarry-Rivera, K.V. Montano-Martinez, S. Alzate-Drada, F. Andrade, *A Case Study of Residential Electric Service Resiliency thru Renewable Energy Following Hurricane María*, Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion (MEDPower), Dubrovnik (Cavtat) Croatia, Nov. 12-15 2018.
[33] There was no electricity nor communications, therefore no Internet, in Puerto Rico for close to a month after Hurricane María.

same amount of energy. The cost of using a set of gasoline generators to provide the same energy is less only if electricity from the grid is available within four months of the blackout. This cost comparison does not include labor and transportation cost of procuring fuel and oil, and the labor cost of performing oil changes and refueling the generator. Nor did we assigned a monetary value to lost sleep re-fueling the generator in the middle of the night.

This is one case study out of hundreds, if not thousands, of rooftop solar photovoltaic systems that help the people of Puerto Rico survive a severe natural disaster. **The proposed PAD is designed to make ownership of a rooftop solar photovoltaic system far more expensive that it has to be and therefore to impede the ability to survive hurricanes in Puerto Rico, an island that lies squarely in the hurricane path of the Caribbean Sea** as shown in Figures 9 and 10.

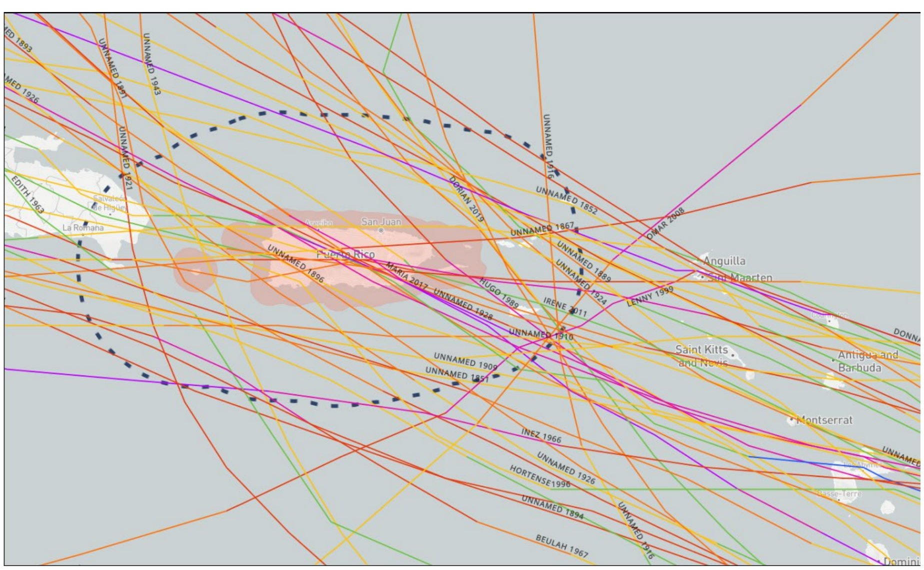

Figure 9. Forty-nine (49) hurricane tracks, from 1842-2021, crossing within 60 nautical miles of the Puerto Rico coast.[34] Note that Hurricane Fiona made landfall in Puerto Rico in 2022 raising the total to fifty (50).

[34] Nat'l Ocean Serv., NAT'L OCEANIC AND ATMOSPHERIC ADMIN. (NOAA), *Historical Hurricane Tracks*, available at www.oceanservice.noaa.gov/news/historical-hurricanes.

Forty-nine (49) hurricanes have crossed nearby Puerto Rico, within 60 nautical miles of its coast from 1842 thru 2021. Eighteen (18) have made landfall during the same period, as shown in Figure 9. Note that Hurricane Fiona made landfall in Puerto Rico in 2022 raising the total of "cross nearby" to fifty (50) and nineteen making landfall. Of the 49 twenty-one (21) were category 3 and higher hurricanes, in the Saffir-Simpson scale, with nine (9) making landfall. Hurricanes categories 3 and higher are described as major hurricanes where near-total to total power loss is likely for weeks.[35]

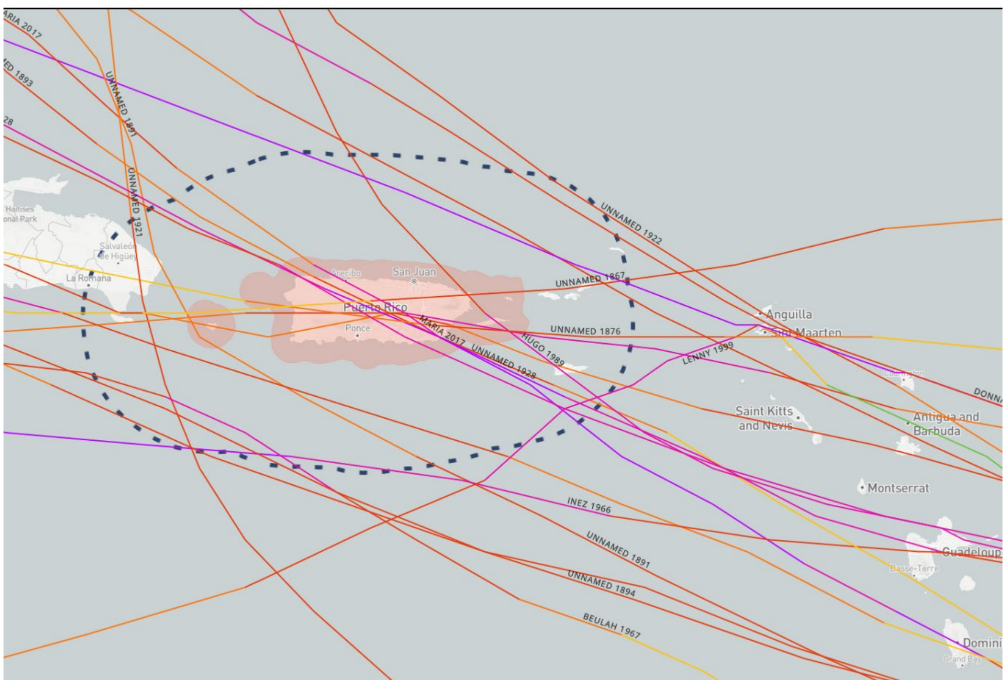

Figure 10. The path of the twenty-one (21) major hurricanes (category 3 and higher), from 1842-2021, crossing within 60 nautical miles of the Puerto Rico coast; nine (9) made landfall.

The people of Puerto Rico should not be penalized for taking advantage of a market driven technological change, the significant drop in the retail price of solar photovoltaic

[35] T. Schott, C. Landsea, G. Hafele, J. Lorens, A. Taylor, H. Thurm, B. Ward, M. Willis, and W. Zaleski, "The Saffir-Simpson Hurricane Wind Scale", National Oceanic and Atmospheric Administration (NOAA), 2012.

systems and batteries, **that allows them to use their clean indigenous resources**, their rooftop and the sun that falls on it, **to generate the totality or a portion of their electric energy needs**. Furthermore, **this technological change provides for increased resiliency of electric energy services after a major hurricane and breaks the "natural monopoly" of the traditional electric utility business**.

Conclusion 9 - Residents of Puerto Rico require a cost effective and resilient alternative to generate electricity and the proposed PAD is an obstacle to achieve this much needed goal.

X. Summary of Conclusions

Conclusion 1 – The proposed PAD fails to analyze, or willfully ignores, current rate of adoption of distributed energy.

Conclusion 2 – Renewable energy adoption policy is harmed by taxing the only renewable energy sector growing for the sake of paying an uninsured debt.

Conclusion 3 – Bondholders are experiencing a technological change they did not foresee. Failure to foresee technological change while investing is not cause to change the bonds guarantee whether the bondholders' claims are secured or not. Nor is it cause to tax the new technology as the proposed PAD does.

Conclusion 4 – Based on Levelized Cost of Energy (LCOE) calculations the proposed "legacy charge" is designed to tax the adoption of residential solar energy and it penalizes net metering adoption of solar photovoltaic rooftop generation.

Conclusion 5 – The LCOE of residential rooftop solar photovoltaic systems, including batteries and using equipment of good warranty and LiFePO4 batteries, already cost less than the cost of electricity from the grid after applying the proposed legacy charge.

Conclusion 6 - Contrary to what is assumed in Exhibit P of the proposed PAD significant grid defection could become a reality in Puerto Rico if the proposed legacy charge is implemented, thus rendering the proposed PAD useless.

Conclusion 7 - Distributed energy systems are currently equal in cost but not in reliability to the electric grid, the electric grid being less reliable. Lack of reliability from the electricity supplied by the electric grid further drives the adoption of rooftop solar PV systems.

Conclusion 8 - The proposed legacy charge will increase the cost of electricity from the electric grid, but will not increase the reliability of this service, thus accelerating the adoption of distributed renewables and probably increasing grid defection, or partial grid defection.

Conclusion 9 - Residents of Puerto Rico require a cost effective and resilient alternative to generate electricity and the proposed PAD is an obstacle to achieve this much needed goal.

Signature

I declare, under penalty of perjury, under the laws of the United States of America, that the foregoing is true and correct. Signed this 28th day of April 2023, in Mayagüez, Puerto Rico,

Agustín Alexi Irizarry-Rivera, Ph.D., P.E.

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XI. Expert Witness Background

Agustín A. Irizarry-Rivera obtained his bachelor, Magna Cum Laude, at Universidad de Puerto Rico Mayagüez (UPRM) (1988), masters at University of Michigan, Ann Arbor (1990) and Ph.D. at Iowa State University, Ames (1996) all in electrical engineering. Since 1997 he has been Professor at the Electrical and Computer Engineering (ECE) Department UPRM where he teaches graduate and undergraduate courses such as: Electric Systems Analysis, Fundamentals of Electric Power Systems, Power System Analysis, Electric Machines, Electrical Systems Design, Advanced Energy Conversion, Power Systems Dynamics and Control and Transmission and Distribution Systems Design.

He has been elected member of the Electrical and Computer Engineering Department Personnel Committee and the School of Engineering Personnel Committee in three occasions and has served as President of both Committees twice. He has been elected Academic Senator to represent the School of Engineering in the Academic Senate. Dr. Irizarry-Rivera has served as Assistant Dean of Academic Affairs and Associate Director for Academic Affairs of the Electrical and Computer Engineering Department at UPR Mayagüez.

Dr. Irizarry-Rivera conducts research in the topic of renewable energy and how to adapt the existing power grid to add more of these resources in our energy portfolio. He had a research internship at Plataforma Solar de Almería, Tabernas, Spain from 2008 to 2009 to study concentrated solar thermal systems. He contributed to the development of dynamic models to simulate the interaction between these plants and the electric grid. He has served as Consultant on renewable energy and energy efficiency projects to Puerto Rico's Government agencies, municipalities, private developers and consulting firms in and outside Puerto Rico. He has also served as expert witness in civil court cases involving electric hazard, shock or electrocution.

Dr. Irizarry-Rivera conducts research in the topic of renewable energy and how to adapt the existing power grid to add more of these resources into our energy portfolio. He had a research internship at Plataforma Solar de Almería, Tabernas, Spain from 2008 to 2009 to study concentrated solar thermal systems. During this research internship he contributed to the development of dynamic models to simulate the interaction between these plants and the electric grid. A few examples of funded research and education projects are:

GEARED (Grid Engineering for Accelerated Renewable Energy Deployment) – (2013-2018) A $929,000 project (UPRM budget out of $6.9 million for the Consortium) to develop and run a Distributed Technology Training Consortium in the Eastern United States, led by the Electric Power Research Institute (EPRI) in collaboration with four U.S. universities (University of Puerto Rico Mayaguez, Georgia Institute of Technology, Clarkson University, University of North Carolina at Charlotte) and seventeen utilities and system operators. The Consortium will leverage utility industry R&D results with power engineering educational expertise to prepare power engineers in management and integration of renewable energy and distributed resources into the grid.

Streamlined and Standardized Permitting and Interconnection Processes for Rooftop Photovoltaic (PV) in Puerto Rico (2012-2013) (Investigator) A $301,911 project sponsored by the US Energy Department that seeks to improve the PV energy market of rooftop systems up to 300 kW in Puerto Rico. The project strives to create not only a standardized framework for PV deployment, but also streamlined: organized, lean permitting and interconnection processes where most residential and small commercial PV systems can be installed safely and quickly.

Design of a Renewable Energy Track within the Electrical Engineering Program at Universidad APEC, Dominican Republic (2011-2012) A $29,000 award to design a Renewable Energy Track within the existing Electrical Engineering Program of UNAPEC.

IGERT: Wind Energy Science, Engineering and Policy (WESEP) (2011-2015) A $171,600 sub-award from Iowa State University, the lead Institution, to fund master students doing research in wind technology, science, and policy as they relate to accomplishing three objectives: (a) increase the rate of wind energy growth; (b) decrease the cost of wind energy; and (c) extend penetration limits.

Achievable Renewable Energy Targets For Puerto Rico's Renewable Energy Portfolio Standard (2007-2009) A $327,197 project sponsored by the Puerto Rico Energy Affairs Administration (Administración de Asuntos de Energía), to produce an estimate, based in realistic boundaries and limitations, of renewable energy available in Puerto Rico for electricity production. The renewable energy resources studied were: biomass - including waste-to-energy, micro hydro, ocean - waves, tides, currents and ocean thermal, solar - photovoltaic and solar thermal, wind – utility as well as small wind, and fuel cells. The purpose of producing these estimates was to establish adequate targets, as a function of time, for Puerto Rico's Renewable Portfolio Standard.

Colegio San Ignacio - Ejemplo de Sostenibilidad (2007-2008) A $73,332 project to match the energy needs of Colegio San Ignacio with its available renewable energy sources. Demonstration projects with a strong educational component were designed for the School with the participation of the School Faculty and students. The philosophy of the program was of sustainable development.

Programa Panamericano de Capacitación en Ingeniería de Potencia Eléctrica (2006-2008) A $97,370 educational project to deliver a Web-broadcast master program in electric power engineering to engineers at UNAPEC University in the Dominican Republic. Courses in this program responded to the reality and necessities of the Dominican Republic electric power industry and were aimed for sustainable development.

Caguas Sustainable Energy Showcase, Phase I (2006-2007) A $90,055 project sponsored by the Municipality of Caguas, Puerto Rico to assess the current electric energy consumption profile, by sector; residential, commercial, industrial and governmental, of Caguas and to propose achievable goals (percentages of demand), by sector, to be satisfied using renewable energy sources.

Intelligent Power Routers for Distributed Coordination in Electric Energy Processing Networks (2002-2005) A $499,849 project sponsored by the National Science Foundation (NSF) and the Office for Naval Research (ONR) to develop a model for the next generation power network using a distributed concept based on scalable coordination by an *Intelligent Power Router* (IPR). Our goal was to show that by distributing network intelligence and control functions using the IPR, we will be capable of achieving improved survivability, security, reliability, and re-configurability. Our approach builds on our knowledge from power engineering, systems, control, distributed computing, and computer networks.

He has served as Consultant on renewable energy, energy efficiency and electric grid performance and operation to Puerto Rico's Government agencies, municipalities, private developers and consulting firms in and outside Puerto Rico. He has also served as expert witness in civil court cases involving electric hazard, shock or electrocution.

He is author or coauthor of over 50 refereed publications including two book chapters (see complete list in the CV section). A licensed professional engineer in Puerto Rico since 1991 and member of IEEE he has organized local and international conferences such as the Tenth International Conference on Probabilistic Methods Applied to Power Systems (PMAPS 2008) in Rincón, Puerto Rico. PMAPS Conferences provide a regular forum for engineers and scientists worldwide to interact around the common theme of power engineering decision problems under uncertainty.

Dr. Irizarry-Rivera has received several awards and honors: **Distinguished Engineer 2013** from Puerto Rico's Professional Engineers Society (CIAPR) and **Distinguished Electrical Engineer 2005** from the Electrical Engineering Institute of CIAPR in recognition of services rendered to the profession and outstanding professional achievements in electrical engineering, the **2009 Distinguished Alumni Award** from UPRM Alumni Association, the **2004 Professional Progress in Engineering Award** from Iowa State University, in recognition of outstanding professional progress and personal development in engineering as evidenced by significant contributions to the theory and practice of engineering, distinguished service rendered to the profession, appropriate community service, and/or achievement in a leadership position and the 2003-2004 ECE **Outstanding Faculty Award** from UPRM's School of Engineering.

In May 2012 he was elected, by the consumers, to the Board of Directors of the Puerto Rico Electric Power Authority, in the first election of this kind in Puerto Rico, to represent the interests of consumers. He was President of the Board's Audit Committee and an active member of the Engineering and Infrastructure, Legal and Labor Affairs and Consumer's Affairs Committees. In 2013 Board Members elected him Vice President of the Board and he served in this capacity until September 2014 when his term expired.

He is Member of the Board of Directors, in the Interest of Consumers, of PREPA Holdings, LLC, a company registered in Delaware, whose sole owner is PREPA. PREPA Holdings owns PREPANET a communications network infrastructure provider that uses an optical network platform in Puerto Rico to provide wholesale telecommunication services.

Dr. Irizarry Rivera is being paid $150 per hour for his services in this case.

XII. Expert Witness CV

Please refer to attached CV **(Exhibit 2).**